Science of the Total Environment 674 (2019) 211–212

Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

Examine all available evidence before making decisions on sunscreen ingredient bans

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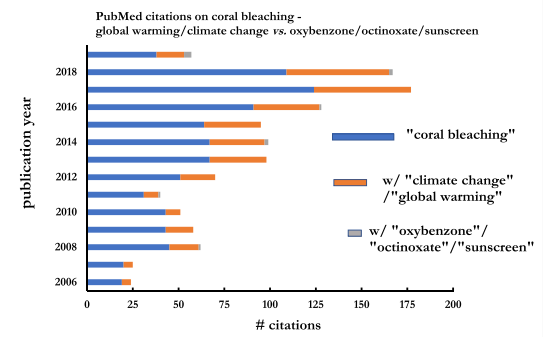
HIGHLIGHTS

- Coral bleaching resulting from climate change has occurred worldwide for decades.
- Recent *in vitro* studies suggest sunscreen ingredients could cause coral to bleach.
- Sunscreen ingredient bans are likely to be ineffective in restoring coral health.
- Ingredient bans will likely result in decreased use and increased UV exposure.
- All scientific evidence needs to be considered before banning sunscreen ingredients.

GRAPHICAL ABSTRACT



ARTICLE INFO

Article history:
Received 15 February 2019
Received in revised form 6 April 2019
Accepted 9 April 2019
Available online 10 April 2019

Editor: Jay Gan

Keywords:
Coral reef
Sunscreen
Oxybenzone
Octinoxate
Ban

ABSTRACT

Coral bleaching is a worldwide problem and more needs to be done to determine causes and potential solutions. A myopic focus on sunscreen ingredients as the proximate cause of coral bleaching provides consumers a false belief that enacted bans of these ingredients will erase decades of coral reef decline. Instead, these bans will likely only lead to decreased sunscreen use and exposure to potentially harmful UV radiation. A closer examination of all available evidence on the causes of coral reef bleaching needs to be undertaken, including a more thorough appraisal of studies conducted under artificial conditions using higher concentrations of sunscreen ingredients.

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Coral bleaching is a worldwide problem and more needs to be done to determine causes and potential solutions. To date, limited evidence generated in laboratory studies suggests that active ingredients in sunscreens are responsible for coral bleaching (Downs et al., 2016; Danovaro et al., 2008; He et al., 2019a; He et al., 2019b; Tsui et al., 2017). Despite this, widespread media attention has focused on results from these studies often using single, unreplicated data points to suggest that ingredients in sunscreen pose a hazard to coral reefs and should thus be banned. Although results from these studies merit consideration, and suggest the need for further study, as with all scientific evidence, there are inherent limitations and results from these studies cannot be easily extrapolated to what might occur in a native coral reef setting. Instead of relying on results from isolated studies to

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https://doi.org/10.1016/j.scitotenv.2019.04.137
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promote proposed solutions to coral decline, a closer examination of all available evidence on the causes of coral reef bleaching should be undertaken. This should include a more thorough appraisal not only of these studies, conducted under artificial conditions using higher concentrations of sunscreen ingredients, but also of other evidence demonstrating the significant role that climate change and other factors have played in coral bleaching over the past 50 years.

Unfortunately, coral reef bleaching has occurred worldwide for the past several decades irrespective of whether a particular coral reef is impacted by a high level of human recreational activity (Bruno and Valdivia, 2016; Barkley et al., 2018). There is a vast amount of scientific evidence pointing to changes in ocean temperature resulting from climate change as a primary mediator of coral reef bleaching (Hughes et al., 2017; Heron et al., 2018; National Oceanic and Atmospheric Administration (NOAA), n.d.; National Aeronautics and Space Administration (NASA), n.d.; Heron et al., 2018). Further, results from other studies (Johnsen, 2018; et al., 2017; Reef Safe, 2016) suggest that exposure to sunscreens (including those that contain oxybenzone or octinoxate) does not negatively affect coral reef populations. In some cases, these experiments utilized exposure conditions which more closely reflected what might happen in a native coral reef setting and found no difference in the health of coral between sunscreen and control groups. Moreover, recent evidence demonstrating lower levels of sunscreen ingredients (including oxybenzone and octinoxate) in coral reef habitats (Mitchelmore et al., 2019) compared to earlier work suggests the need for careful examination of all available data.

Banning individual sunscreen ingredients based on preliminary results obtained under conditions which may not accurately reflect native coral reef settings is highly irresponsible, as it risks the diversion of resources towards efforts which will likely have no measurable effect. Further, reducing the number of available sunscreen ingredients will inhibit consumer choice of broad-spectrum sunscreen products shown to be effective in reducing skin cancer (Green et al., 2011; Van der Pols et al., 2006; Olsen et al., 2018; Watts et al., 2018).

One in five people will develop skin cancer in their lifetime and more than 5 million new cases of skin cancer were diagnosed in the U.S. in 2018 (American Cancer Society, Cancer Facts, and Figures, 2018). There are more new cases of skin cancer each year than breast, prostrate, lung and colon cancer combined. Overwhelming evidence demonstrates that excess sun exposure without sunscreen increases the risk of developing skin cancer in both adults and children (Preston and Stern, 1992; English et al., 1998). Sun-protective behaviors to reduce exposure to harmful UVA and UVB radiation should be practiced whenever possible and sunscreens are one effective option. Dermatologists agree that the best sunscreen is the one that is used on a regular basis.

A broad array of healthcare professionals recommends using a broad-spectrum sunscreen daily to prevent against sunburn and skin cancer. Indeed, a recent survey of dermatologists (Farberg et al., 2016) found that 99% agreed that regular use of sunscreen helps lower skin cancer risk. Similarly, a diverse group of professional societies/expert bodies recommends use of a broad-spectrum sunscreen to help protect against the harmful effects of UV radiation and reduce the risk of skin cancer.

When viewed in its entirety, the currently available evidence on the causes of coral reef bleaching and mortality, in Hawaii, Florida and the world over, overwhelmingly demonstrates that climate change (Hughes et al., 2017) is primarily responsible. There is evidence suggesting that other factors such as ocean acidification (Cyronak et al., 2018), runoff (Brodie et al., 2010; De'ath and Fabricius, 2010; Fabricius, 2005) and sewage discharge also contribute to an overall decline in coral reef populations. Coral damage resulting from runoff or sewage discharge could be a consequence of numerous factors (Marques et al., 2019) including changes in salinity (Aguilar et al., 2019) or bacterial count (Staley et al., 2017).

An open, honest and unbiased discussion of the available science on the multifactorial causes of coral reef bleaching and possible solutions to this problem needs to be conducted. The current focus on implicating chemical sunscreen ingredients as the proximate cause of coral bleaching provides consumers a false belief that enacted bans of these ingredients will erase decades of coral reef decline. Instead, these bans will likely only lead to decreased sunscreen use and increased exposure to potentially harmful UV radiation.

Acknowledgements

The Consumer Healthcare Products Association (CHPA) is the 138-year-old national trade association representing the leading manufacturers and marketers of over-the-counter (OTC) medicines (including sunscreen manufacturers).

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